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SYSTEM FOR DETECTING HEADPHONES FOR HRTF RENDERING

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ABSTRACT

Head-related transfer functions (HRTF) describe the changes in a sound wave as it propagates from a spatial source to the eardrum of a human. With many portable user devices, such as laptop computers, tablet computers, and the like, it has become more common to use HRTF for any audio rendering performed with the devices, as doing so significantly improves the listening experience for the user. However, in such applications it is imperative that the user device knows whether the rendering is performed over headphones or over free-standing loudspeakers. Accordingly, the system and method described in this publication relates to a headphone detection algorithm that determines whether a played out audio signal is present in the microphone signals of the rendering device.

***Index Terms*: head-related transfer function, HRTF, headphones, audio signal rendering**

INTRODUCTION

Audio delivery can be performed by means of free-standing audio output devices (e.g., loudspeakers) or by means of audio output devices worn on or carried by the body of users (e.g., headphones). Recently, there has been a strong trend towards using head-related transfer functions (HRTF) for audio rendering with headphones, as such a technique greatly improves the listening experience for the user. The signal that is played out over headphones when a HRTF is used differs significantly from that played out over a stereo loudspeaker system. Particularly

when using portable devices such as laptop computers, tablet computers, and the like, the same audio output is used for playing out over self-powered loudspeakers as is used for playing out over headphones. Thus, the portable device does not know if the signal is rendered by a headphone or a set of free-standing loudspeakers. As such, a detection mechanism or technique is needed to determine if a loudspeaker or a set of headphones is being used.

DESCRIPTION OF THE SYSTEM

The system described in this publication relates to a headphone detection system and method that determines whether a played out audio signal is present in the microphone signals of the rendering device. Such a determination can be made by using the same basic technology that is already available in existing echo cancelers.

Figure 1 shows an example implementation of the headphone detection system and method described in the present publication. It should be noted that if the connection to the device is digital, then the protocol may include information about the type of rendering device. However, this is not the case for the common analog connection. Therefore, at least in an initial implementation, the system would render the audio signal assuming freestanding loudspeakers are used. For example, the system detects dependencies between the signal(s) acquired by the microphone(s) and the two (stereo) rendered signals by comparing the joint statistics of their concurrent and causally delayed power spectra. If it is determined that the dependencies exceed a threshold, then the signal is played out over free-standing loudspeakers. On the other hand, if it is

instead determined that the dependencies do not exceed the threshold, the signal is played out over headphones.

In other implementations, it would be possible to use simplified versions of the algorithm where the system looks only for characteristic onsets of the signal. Such simplifications of the system would reduce the overall computational effort.

An alternative approach to the system and method described is to detect the presence of headphones using visual means. However, one problem with such an approach is that visual detection is a difficult task in this context. For example, a user's hair may be misinterpreted as headphones or may conceal headphones, the headphones may be small or shaped in an unusual manner, etc. The audio approach disclosed above is more straightforward and provides more accurate results.

Using head-related transfer functions (HRTF) for audio rendering is useful in many contexts, including, for example, video conferencing applications and/or services, as well as with video content sharing websites. In both contexts, it is important that the computing device (e.g., laptop computer, tablet computer, etc.) knows if the rendering is performed over headphones or free-standing loudspeakers. Therefore, it is understandable that the disclosed headphone detection algorithm would be an integral component of the HRTF system.

DIAGRAM

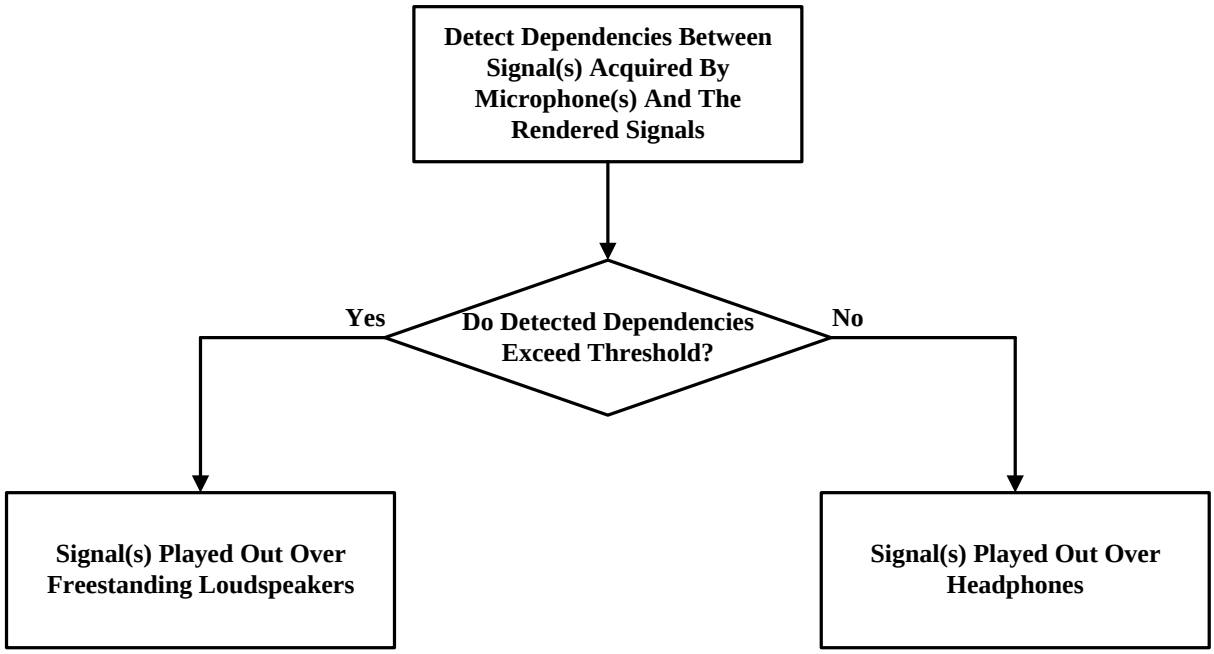

Figure 1: Headphone Detection Algorithm